A NEW METHOD
OF
DETERMINING THE DEPTH OF THE GREY MATTER
OF THE
CEREBRAL CONVOLUTIONS.

By HERBERT C. MAJOR, M.B.,

ASSISTANT MEDICAL OFFICER, LATE CLINICAL ASSISTANT, WEST RIDING ASYLUM.

On reviewing what has been done in the investigation of the cortical substance of the human brain, in its healthy and in its morbid state, with reference to that great function which we know it to exercise, one cannot help being struck by the fact that although much has been done, and vast is the store of accumulated facts which have, especially of late years, been amassed, much has yet to be discovered.

On entering on this subject, facts and observations are not wanting which seem, at first sight, to point to a definite conclusion; but in whatever direction we may have advanced, and however pleasant the path may seem, there comes a check to further progress; it may be soon or it may be late, but almost invariably it does come. It is so in the physiology of the brain, and it is the same in its morbid anatomy.

With respect to the healthy brain, few questions have arisen having a deeper interest than those, the object of which is to ascertain to what extent the degree of intellect possessed by an individual during life may be estimated by an examination of the brain after death. As yet this inquiry has been limited chiefly to a consideration of size, weight, and general conformation. The point has been very fully brought out by the researches of Wayner and others, and is a conclusion which we

can scarcely avoid, that, as a general rule, great intellectual power is associated with a large and heavy brain; and on the other hand, that in the lower races of mankind, in whom the intellect is less highly cultivated, a smaller and less perfectly developed organ is usually found. Unfortunately however, this is by no means an invariable rule, for instances are not wanting in which the brain representing superior intellect has not only not surpassed another, lower in the intellectual scale, but has even fallen below it. Exceptions of this nature differ from those which belong to rules in general; for here we cannot be content to have the fact, and as such, accept it without further inquiry. However numerous the instances in which the rule as previously stated, holds good, if we admit the fact of an exception, it is for us to explain how such an exception may arise; and if we are unable to do this, we must confess, that other conditions of whose nature we are ignorant, may exist and play an important part.

In the second place, the number and depth of the cerebral convolutions have called forth special attention; for here also, as with respect to size, it has been found that increased depth and number of the convolutions coincides, in many instances, with superior intellectual power. But here again, having arrived at a general conclusion, based on observations which are good and true, we are met by the stern fact that this is not always so, and that instances are not wanting in which the exact opposite has been the case. These are instances in which the difficulty comes late; a general conclusion is arrived at, but is marred by exceptions which we are unable to explain.

But with regard to the grey cortical layer, other questions besides that of extent demand consideration. In histology considerable strides have of late years, and are still being made, chiefly owing to the excellence of modern instruments and improved methods of research. But although we are now enabled to study the minute structure of the nervous system with considerable accuracy, and although the grey matter of the human cerebrum has been the subject of extensive and elaborate investigation, when the question arises as to the difference histologically between two brains, one of which represents a high, the other a low standard of intellect, we are

compelled to admit that the answer to the question lies beyond our reach.

The specific gravity of the cortical layer has of late been the subject of careful consideration, but as yet I am not aware that differences have been detected corresponding with gradations in mental capacity.

Passing now to the consideration of the brain in its pathological condition, however true it may be that there is usually found after death, some condition or conditions which are most assuredly abnormal, and which we can, to a certain extent, connect with morbid processes present during life; yet it is also true that cases may, and do occur when we find ourselves at fault, when either all our methods of observation fail to elicit anything abnormal, or when there is a seeming contradiction given to those views which experience has shown, in the majority of cases, to be correct.

From these considerations it follows that we may have presented to us for examination two brains, equal in size and weight; equal also, so far as can be ascertained, in the number and depth of the convolutions—that is to say, in the extent of the grey matter, the latter being also similar in its minute structure; and yet one may represent great intellectual power, the other quite an opposite condition. Further still, it may occur that a brain, in a morbid state, presents characters not to be distinguished from those in health. It is in such cases as these that we feel the force of the fact, that however important those conditions which we can appreciate may be, others exist, of the nature of which we are still ignorant; and that, while at it were digging deeper in the old channels with those materials which we already possess, no opportunity should be neglected of bringing others to bear, and by their means striking out new channels of investigation, further and further elucidate and estimate the importance of those points on which our knowledge is still deficient.

It will be observed that, in the course of these remarks, no observation has been made with reference to the depth of the grey matter of the convolutions, and this brings me more immediately to the subject of my paper. I am not aware that any extensive and accurate observations have been made in

order to ascertain the exact depth of the cortical layer, and yet the importance of such an inquiry, whether in a physiological or in a pathological point of view, can scarcely be questioned. It is, I think, quite possible that by a closer inquiry into this point we may find a solution of the difficulty, and an explanation of some of those troublesome exceptions to which I formerly referred. For example, in cases in which *a priori* one would expect to find differences in size and in the number and depth of the convolutions, and yet no such difference can be detected, I think it quite possible, and even probable, that accurate measurement would demonstrate a variation in the depth of the cortical layer, and if this could be proved, the exception would be satisfactorily accounted for, and the difficulty, I conceive, removed. It may be that I am wrong in this, and that actual experience may show the impracticability of demonstrating a difference of such nicety; but when we pass out of the region of health into that of disease, there can be no doubt, as I hope to show, that differences do exist in this respect; and such being the case, I see no reason why variations should not occur, although it may be to a very slight extent, under normal circumstances; and in any case, if this be probable, or even only possible, it is well worthy of our closest and most searching inquiry.

It had been observed, during the course of an investigation with the specific gravity of the brain,

1st. That in the same organ the depth of the grey matter varied considerably in different situations, and

2nd. That in different brains the relative depth in corresponding situations seemed to differ.

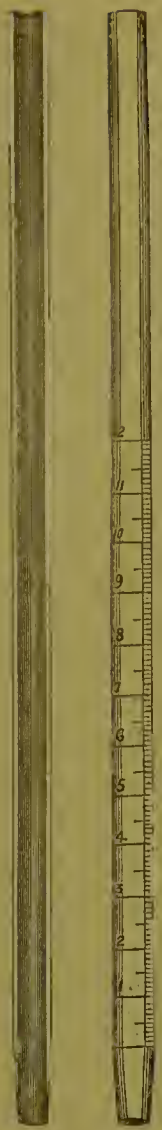
The question now arose—By what means could the thickness of the cortical substance be readily and accurately measured? the desideratum being an instrument, which should enable the operator to combine ease and rapidity with accuracy of investigation. I may say shortly, that, with this object in view, I was led to devise an instrument which I have called the Tephrylometer[1] (τεφρά ash coloured, ὑλη matter), and which, I venture to think, fulfils the required conditions; and

[1] For the suggestion of this word I am indebted to the kindness of Dr. James P. Steele.

it will now be my endeavour, in the first place, to explain its construction; in the second place, the method of using it; and lastly to adduce a few results which, by its means, have been obtained.

The peculiarity of the instrument consists in its extreme simplicity. It is nothing more than a graduated glass tube, open at both extremities. Its length, as I now use it, is five inches. This however is merely an arbitrary standard. The first I used was only four inches in length, and answered the purpose very well. On the whole, however, I am inclined to think the five inch measurement preferable. The wall of the tube is in thickness about equal to that of a goose quill, or a little thicker, except for about a quarter of an inch at one extremity, where it is bevelled off in such a manner, that this end of the tube presents an orifice surrounded by a smooth and tolerably sharp margin. At the opposite extremity, the tube wall retains its usual thickness, not being in any way bevelled off. The graduation, which is on a fiftieth of an inch scale, extends over half the length of the instrument, commencing at a distance of a quarter of an inch from the piercing or bevelled off extremity. The graduated lines are made black so as to show out more distinctly, and each fifth degree, that is to say every tenth inch mark, is longer and more conspicuous than the intermediate ones. The bore of the tube is everywhere of uniform size, and this is a point of all importance; for should the calibre at all diminish at the piercing extremity, the instrument is worthless. The *wall* of the tube should taper, the *calibre* must not. The above description applies to all sizes of instrument, the point on which they differ, viz., the diameter of the bore, not having been considered. At present I am in the habit of using three sizes, which I call respectively Nos. 1, 2, and 3. No. 1 is the largest; in it the diameter of the bore measures eight fiftieths of an inch; in No. 2 it is six fiftieths, and in No. 3 five fiftieths. The necessity, or at least the advisability, of having different sizes will be explained hereafter.

The following drawings represents No. 1 instrument, and an examination of them will at once explain any points which my description may have failed to make clear :—



B A

Before considering the more special *modus operandi*, there are two points which claim attention. The first has reference to the preparation of the brain. It is essential that the organ should be stripped thoroughly and completely of its Pia-mater. This in most cases is a matter of no difficulty, but on the other hand, may be exceedingly troublesome to accomplish. There are two chief conditions which may prove a source of difficulty. The first is extreme tenuity and delicacy of the membrane, which exists to a greater or less extent in all healthy brains, and is also met with, though exceptionally, associated with a morbid condition of that organ. This condition demands care and patience on the part of the operator. Should much trouble be experienced, the process should be carried on under water, as by this means the delicate pieces of Pia-mater are floated up, and can be removed with greater facility.

The second source of difficulty is more serious. I refer to the presence of adhesion between the Pia-mater and the subjacent cortical substance. It may be so slight as to present little or no opposition to the stripping process; but on the other hand, the adhesions may be so firm and dense as to render removal of the membrane, without injury to the brain substance, a matter of the utmost difficulty or even impossibility. For such cases I must at once admit, my method is not suited. It is difficult indeed to conceive any method, by means of which, under these circumstances, the measurements could be fully carried out; for to any process, the presence of adhesion must offer a very serious impediment. To such an extent, however, it is exceptional; in general, when present, it is slight or moderate in amount, and demands—as in the cases before referred to, in which the

Figure A represents the instrument *in situ*.
Figure B the same, on longitudinal section.

membrane is unusually fine—a proportionate amount of patience and care. In all cases, after the stripping process is complete, the brain should be slightly washed in water, so as to remove blood, &c., the presence of which, by clouding the instrument, would tend to obscure the observations.

The second point I wish to notice has reference to the size of instrument to be employed. It need scarcely be said that the size of a frontal or parietal convolution is considerably greater than that of an occipital; and now the object of having tubes of different sizes will be evident; for an instrument which serves very well for the former, will be too large for the latter. It may be urged, and very reasonably, that an instrument adapted to the smaller convolutions should be equally so to the larger; nevertheless, experience on the whole, has led me to prefer the larger tubes when possible; I must admit however that it is not essential.

Having now fixed on the convolution, the grey matter of which it is desired to estimate, take the instrument selected between the ring and middle fingers and the thumb of the right hand, and, holding it vertically to the surface of the convolution, and with the sharp extremity downwards, pierce the convolution as nearly as possible in the middle line, making the instrument bury itself, to about half its length, in the cerebral substance. This movement may, with a little practice, be performed with great rapidity and precision; as a rule however, I prefer to do it more slowly, imparting to the instrument as it penetrates the grey matter, a slight rotatory motion, so as to facilitate its passage; but in any case when the cortical substance has been traversed, the movement should be completed somewhat rapidly. By this, which constitutes *the first movement*, the cerebral substance is pierced, and passes into the interior of the instrument during the downward progress of the latter.

The second movement now follows, and is thus performed:—Still holding the tube as before directed, the right forefinger is made to descend so as to close the projecting orifice; and in order to effect this more completely, it is desirable that the pulp of the forefinger should be moist, for on the thorough closure of this orifice everything depends. This constitutes the *second movement*, and by it as will be at once apparent, one change

only is brought about, viz., the conversion of an open into a closed tube.

The *third movement* consists simply in the withdrawal of the entire tube, the hand being retained in exactly the same relation to the instrument as in the previous movement. The direction of the long axis of the tube should, as far as possible, be retained throughout all three movements.

There corresponds to this movement—

1st. Commencing withdrawal of the tube.

2nd. Formation of a vacuum within the tube.

3rd. Rupture of the cerebral white matter at the lower orifice.

4th. Complete withdrawal of the instrument.

It will be at once seen that these movements are of the simplest kind, and essentially they never vary. As regards some of the secondary points however, such as the position of the fingers in the first movement, although I have stated that the middle and ring fingers of the right hand should be made to oppose the thumb, it is right I should add that it is not a point of much consequence. The fore and middle fingers or the forefinger only, may be used with the thumb, the only disadvantage being that a little additional movement of the right forefinger is rendered necessary; this however is rather a theoretical than a practical objection. When possible, it is always best to pierce downwards; but in some situations this cannot easily be done, and in the latter case the position of the fingers may conveniently be varied to meet the convenience of the operator.

With regard to the third movement, it should be performed somewhat suddenly and rapidly, as by so doing the cerebral white matter is ruptured with greater certainty.

The above directions having been properly carried out, on examination of the instrument, its lower part will be found occupied by cerebral substance, the grey portion of which is distinctly seen and must now be measured. This is done by holding the tube in such a position that the graduation may be in full view, when nothing remains but to read off the number of fiftieths of an inch occupied by the grey matter of the specimen.

In reading off the number of degrees, I am in the habit of using a lens—any ordinary pocket lens answers the purpose perfectly. It is not by any means essential to the process, still, after having worked for some time, the eye is apt to become somewhat fatigued, and this I find is altogether obviated by the use of a low magnifying power.

Having now completed the observation, it is necessary to clear the instrument previous to repeating the process. This is effected by blowing through the tube, by which means the contained substance is projected, leaving the instrument slightly hazy. This haziness is at once and completely removed by dipping the end for a second or two in water, a glass of which fluid should be placed conveniently for the purpose. The piece of cerebral substance so discharged retains its form perfectly, and may be kept if desired for further examination, being blown into spirit or other preservative.

The whole process as above described, may, with a little practice, be performed very rapidly. I have myself frequently recorded an observation, and prepared the instrument for the next, within thirteen seconds; but this is of course needlessly quick, and could not be repeated often in succession, without greatly endangering that accuracy, which in this, as in all other investigations of like nature, is of the last importance.

It may be well to notice here a source of error against which it is necessary to guard in making these observations. It was formerly stated that care should be taken to pierce the convolution as nearly as possible in the middle line. The reason for this will be evident when the structure of a convolution is considered; for if this point be not attended to, the piercing tube will encounter and include part of the grey matter forming the lateral boundary of the convolution, and the result will be, that the portion of grey matter within the tube, instead of being uniform in thickness, will be uneven, and deeper at one part of the circumference of the tube than at another. It is on this account that I prefer to perform the first movement, in part at least, somewhat slowly; and more especially is this precaution advisable when the smaller convolutions, such as those of the occipital lobes, are under examination; in any case, however, due regard being paid to this point, and

care being taken to select the instrument in accordance with the size of the convolution to be pierced, this source of error will not occur.

I now pass to consider the mode of procedure in estimating the *average* depth of the cortical substance, in all or any of the convolutions. Little however need be added to those general directions which I have already given; for the method I adopt will at once be understood, on referring to the examples I have recorded. I do not consider it sufficient to take one specimen from any convolution, and to attempt therefrom to draw a conclusion; but I take several measurements, varying in number according to the size of the convolution, and then ascertain the mean depth of grey matter in the specimens so taken. It is however a question of interest, and one which I have not as yet determined, how far the depth of any one specimen will represent the *average* depth in the convolution from which it was taken. The Cerebellum should not be removed, unless required for other purposes; for it serves to steady the brain, and to prop up the posterior lobes, and thus considerably facilitates the process in this situation. I usually commence at the frontal convolutions and proceed in regular order backwards; first finishing the upper surface of one hemisphere before commencing the other. This is not a point of great importance, still it must be remembered that the brain in its recent state, especially when deprived of its Pia-mater, is always soft, and any unnecessary handling is to be avoided. For the same reason I always finish the upper surface of both hemispheres previous to commencing at the base. It is a point of some advantage to have a list of the various convolutions drawn out before hand, with a space opposite each for recording the numbers. In many cases it is not possible to have assistance, and I do not think it necessary, care being taken to render each step as simple as possible: It need scarcely be said that the process I have described, if fully carried out, is one of some length. It cannot be otherwise when the examination of a single brain comprises upwards of 220 distinct observations. But the question is not whether the absolute amount of time required be considerable, but rather, if it is disproportionate to the importance of the question to be determined. The answer to this question must, I think, be in the negative.

The following tables represent the examination of the brain, as conducted on the principles I have laid down, in four cases. The numbers in each case which correspond to the individual convolutions, represent accurately the measurements taken; but in estimating the depth of the grey matter in the various lobes and groups of convolutions, the numbers are given approximately, very minute fractions (of a fiftieth of an inch) not being considered:—

Brain of J. M. H. S. (Acute Mania).

Depth of Grey matter (in 50ths of an inch).

Convolutions.	Right Hemisphere.	Mean Depth	Left Hemisphere.	Mean Depth
1st Frontal	6.6.5.5.5.5.	$\frac{5\frac{1}{3}}{50}$	6.6.5.6.6.5.	$\frac{5\frac{1}{6}}{50}$
2nd ,,	5.5.5.5.5.6.	$\frac{5\frac{1}{6}}{50}$	5.5.5.6.5.5.	$\frac{5\frac{1}{6}}{50}$
3rd ,,	6.6.5.7.5.5.	$\frac{5\frac{2}{3}}{50}$	6.6.5.6.5.5.	$\frac{5\frac{1}{2}}{50}$
Ascending Frontal	6.6.6.6.6.5.	$\frac{6}{50}$	6.6.6.7.6.6.	$\frac{6\frac{1}{3}}{50}$
,, Parietal	5.5.5.5.5.5.	$\frac{5}{50}$	5.5.6.5.6.5.	$\frac{5\frac{1}{3}}{50}$
Postero-parietal Lobule	6.5.5.5.	$\frac{5\frac{1}{4}}{50}$	5.5.5.5.	$\frac{5}{50}$
Supra Marginal Conv.	6.6.6.7.	$\frac{6\frac{1}{4}}{50}$	5.6.6.5.	$\frac{5\frac{1}{2}}{50}$
Angular Conv.	6.5.5.5.	$\frac{5\frac{1}{4}}{50}$	6.6.5.5.	$\frac{5\frac{1}{2}}{50}$
1st Annectant Conv.	5.5.5.	$\frac{5}{50}$	5.5.5.	$\frac{5}{50}$
2nd ,, ,,	5.6.6.	$\frac{5\frac{1}{3}}{50}$	6 6.5.	$\frac{5\frac{2}{3}}{50}$
3rd ,, ,,	5.5.6.	$\frac{5\frac{1}{3}}{50}$	5.5.5.	$\frac{5}{50}$
Superior Occipital	4.4.4.	$\frac{4}{50}$	4.5.5.	$\frac{4\frac{2}{3}}{50}$
Middle ,,	4.4.4.	$\frac{4}{50}$	5.4.4.	$\frac{4\frac{1}{3}}{50}$
Inferior ,,	5.4.4.	$\frac{4\frac{1}{3}}{50}$	5.4.4.	$\frac{4\frac{1}{3}}{50}$
Supr.-temporal Sphenoidal	6.6.6.6.	$\frac{6}{50}$	5.6.6.5.	$\frac{5\frac{1}{2}}{50}$
Middle ,, ,,	6.5.5.6.	$\frac{5\frac{1}{2}}{50}$	6.5.6.5.	$\frac{5\frac{1}{2}}{50}$
Inferior ,, ,,	5.5.5.6.	$\frac{5\frac{1}{4}}{50}$	5.6.6.5.	$\frac{5\frac{1}{2}}{50}$
Orbital Lobe, Marginal Conv.	4.4.4.	$\frac{4}{50}$	4.4.4.	$\frac{4}{50}$
,, ,, Internal ,,	5.4.4.	$\frac{4\frac{1}{3}}{50}$	5.4.4.	$\frac{4\frac{1}{3}}{50}$
,, ,, External ,,	5.5.5.	$\frac{5}{50}$	5.5.4.	$\frac{4\frac{2}{3}}{50}$
,, ,, Posterior ,,	4.5.4.	$\frac{4\frac{1}{3}}{50}$	6.6.4.	$\frac{5\frac{1}{3}}{50}$
Central Lobe, Antr. Conv.	7.7.	$\frac{7}{50}$	6.6.	$\frac{6}{50}$
,, ,, Middle ,,	6.6.	$\frac{6}{50}$	7.5.	$\frac{6}{50}$
,, ,, Posterior ,,	6.5.	$\frac{5\frac{1}{2}}{60}$	6.5.	$\frac{5\frac{1}{2}}{50}$
Marginal Convolution	5.5.5.5.	$\frac{5}{50}$	5.5.5.4.	$\frac{4\frac{3}{4}}{50}$
Gyrus Fornicatus	5.5.5.5.	$\frac{5}{50}$	5.5.6.	$\frac{5\frac{1}{3}}{50}$
Quadrilateral Lobule	5.5.6.	$\frac{5\frac{1}{3}}{50}$	4.4.5.	$\frac{4\frac{1}{3}}{50}$
Cuneate Lobe	5.4.3.	$\frac{4}{50}$	4.3.4.	$\frac{3\frac{3}{4}}{50}$
Uncinte Cyrus	3.4.3.	$\frac{3\frac{1}{3}}{50}$	3.4.4.	$\frac{3\frac{2}{3}}{50}$
Internal Temporal Convolutions	4.4.4.5.	$\frac{4\frac{1}{4}}{50}$	5.5.5.5.	$\frac{5}{50}$

Brain of J. B. (Senile Dementia).

Depth of Grey Matter (in 50ths of an inch).

Convolutions.	Right Hemisphere.	Mean Depth	Left Hemisphere.	Mean Depth
1st Frontal	5.7.6.6.7.5.	6/50	6.6.7.5.6.5.	6/50
2nd ,, ...	5.6.6.5.6.4.	5⅓/50	5.6.5.6.5.5.	5⅓/50
3rd ,, ...	6.6.4.5.6.5.	5⅓/50	5.5.5.5.4.5.	5/50
Ascending Frontal	6.6.5.6.7.5.	6/50	5.6.6.6.5.6.	5⅚/50
,, Parietal	5.5.5.5.5.5.	5/50	5.5.5.4.5.4.	4⅔/50
Postero-parietal Lobule	5.5.5.	5/50	5.6.5.	5⅓/50
Supra Marginal Conv.	4.4.5.	4⅔/50	5.5.5.	5/50
Angular Conv.	6.5.	5½/50	6.5.	5½/50
1st Annectant Conv.	4.4.	4/50	5.4.	4½/50
2nd ,, ,, ...	5.5.4.	4⅔/50	6.5.5.	5⅛/50
3rd ,, ,, ...	4.5.5.	4⅔/50	4.4.5.	4⅓/50
Superior Occipital	4.3.3.	3⅓/50	4.3.3.	3⅓/50
Middle ,, ...	4.4.3.	3⅔/50	4.4.3.	3⅔/50
Inferior ,, ...	4.4.3.	3⅔/50	4.5.4.	4⅓/50
Temp. Sphenoid Lobe Sup. Conv.	5.5.5.5.5.	5/50	6.4.5.5.5.	5/50
,, ,, ,, Middle ,,	5.5.5.4.5.	4⅘/50	6.5.5.4.4.	4⅘/50
,, ,, ,, Inferior,,	5.5.5.4.4.	4⅗/50	4.4.5.4.4.	4⅕/50
Orbital Lobe, Marginal Conv. ...	4.3.4.	3⅔/50	4.4.3.	3⅔/50
,, ,, Internal ,, ...	3.4.4.	3⅔/50	4.4.4.	4/50
,, ,, External ,, ...	3.3.3.	3/50	4.4.4.	4/50
,, ,, Posterior ,, ...	5.5.4.	4⅔/50	4.4.4.	4/50
Central Lobe, Antr. Conv. ...	6.6.	6/50	7.6.	6½/50
,, ,, Middle ,, ...	6.5.	5½/50	5.6.	5½/50
,, ,, Posterior Conv. ...	4.5.	4½/50	4.6.	5/50
Marginal Convolution	5.5.6.	5⅓/50	5.6.6.	5⅔/50
Gyrus Fornicatus	5.5.5.	5/50	5.5.5.	5/50
Quadrilateral Lobule	5.4.5.	4⅔/50	5.5.5.	5/50
Cuneate Lobe	3.4.3.	3⅓/50	4.4.4.	4/50
Uncinate Gyrus	4.4.3.	3⅔/50	3.4.3.	3⅓/50
Internal Temporal Convolutions	5.5.5.5.4.4.	4⅘/50	6.5.4.5.4.4.	4⅓/50

Brain of J. M. H. S. (Acute Mania) *Continued.*

Relative depth in the various Lobes and Groups of Convolutions.

	Right Hemisphere.	Left Hemisphere.
Frontal Lobe	$\frac{5\frac{1}{2}}{50}$	$\frac{6}{50}$
Parietal ,, ...	$\frac{5\frac{1}{2}}{50}$	$\frac{5\frac{1}{2}}{50}$
Annectant Gyri	$\frac{5}{50}$	$\frac{5}{50}$
Occipital Lobe	$\frac{4}{50}$	$\frac{4\frac{1}{2}}{50}$
Tempero-Sphenoidal Lobe	$\frac{5\frac{1}{2}}{50}$	$\frac{5\frac{1}{2}}{50}$
Orbital Lobe	$\frac{4\frac{1}{2}}{50}$	$\frac{4\frac{1}{2}}{50}$
Central ,, ...	$\frac{6}{50}$	$\frac{6}{50}$
Marginal Convolution, Gyrus Fornicatus, Quadrilateral Lobule	$\frac{5}{50}$	$\frac{5}{50}$
Cuneato Lobe, Uncinate Gyrus	$\frac{3\frac{2}{3}}{50}$	$\frac{3\frac{2}{3}}{50}$
Internal Temporals	$\frac{4\frac{1}{4}}{50}$	$\frac{5}{50}$
The Hemispheres	$\frac{5}{50}$	$\frac{5}{50}$
Average depth of the whole Cortical substance, = a little over $\frac{1}{10}$ inch.		

Brain of J. B. (Senile Dementia) *Continued.*

Relative depth in the various Groups of Convolutions.

	Right Hemisphere.	Left Hemisphere.
Frontal Lobe	$\frac{6}{50}$	$\frac{5\frac{1}{2}}{50}$
Parietal ,, ...	$\frac{5}{50}$	$\frac{5}{50}$
Annectant Gyri	$\frac{4\frac{1}{2}}{50}$	$\frac{5}{50}$
Occipital Lobe	$\frac{4}{50}$	$\frac{4}{50}$
Tempero-Sphenoidal	$\frac{5}{50}$	$\frac{5}{50}$
Orbital Lobe	$\frac{4}{50}$	$\frac{4}{50}$
Central ,, ...	$\frac{5\frac{1}{3}}{50}$	$\frac{6}{50}$
Marginal Convolutions, Gyrus Fornicatus, Quadrilateral Lobule	$\frac{5}{50}$	$\frac{5}{50}$
Cuneate Lobe, Uncinate Gyrus	$\frac{3\frac{1}{2}}{50}$	$\frac{2\frac{1}{2}}{50}$
Internal Temporals	$\frac{5}{50}$	$\frac{5}{50}$
The Hemispheres	$\frac{5}{50}$	$\frac{5}{50}$
Average depth of the whole Cortical Substance = $\frac{1}{10}$ inch.		

Brain of J. J. (Senile Dementia).

Depth of Grey matter (in 50ths of an inch).

Convolutions.	Right Hemisphere.	Mean Depth	Left Hemisphere.	Mean Depth
1st Frontal...	5.5.6.6.6.5.	$\frac{5\frac{1}{2}}{50}$	6.6.5.6.6.5.	$\frac{5\frac{2}{3}}{50}$
2nd ,, ...	6.6.7.6.5.5.	$\frac{6}{50}$	6.6.5.5.5.5.	$\frac{5\frac{1}{3}}{50}$
3rd ,, ...	5.5.5.5.4.5.	$\frac{5\frac{2}{3}}{50}$	5.6.5.5.5.5.	$\frac{5}{50}$
Ascending Frontal	5.6.6.6.6.5.	$\frac{5\frac{2}{3}}{50}$	5.6.6.6.6.5.	$\frac{5\frac{2}{3}}{50}$
,, Parietal	5.5.5.5.5.5.	$\frac{5}{50}$	5.5.5.5.5.5.	$\frac{5}{50}$
Postero-parietal Lobule	6.5.4.	$\frac{5}{50}$	4.5.5.	$\frac{4\frac{2}{3}}{50}$
Supra Marginal Conv.	5.5.5.	$\frac{5}{50}$	5.6.5.	$\frac{5\frac{1}{3}}{50}$
Angular Conv.	4.5.5.	$\frac{4\frac{2}{3}}{50}$	4.5.5.	$\frac{4\frac{2}{3}}{50}$
1st Annectant Conv.	4.4.4.	$\frac{4}{50}$	5.4.5.	$\frac{4\frac{2}{3}}{50}$
2nd ,, ,, ...	5.5.6.	$\frac{5\frac{1}{2}}{50}$	4.4.4.	$\frac{4}{50}$
3rd ,, ,, ...	5.4.4.	$\frac{4\frac{1}{3}}{50}$	5.4.4.	$\frac{4\frac{1}{3}}{50}$
Supr. Occipital	5.4.4.	$\frac{4\frac{1}{3}}{50}$	4.4.5.	$\frac{4\frac{1}{3}}{50}$
Middle ,, ...	5.4.4.	$\frac{4\frac{1}{3}}{50}$	4.4.4.	$\frac{4}{50}$
Inferior ,, ...	4.5.5.	$\frac{4\frac{2}{3}}{50}$	4.4.4.	$\frac{4}{50}$
Supr. Temp. Sphenoidal... ...	5.5.5.	$\frac{5}{50}$	5.5.5.	$\frac{5}{50}$
Middle ,, ,, ...	5.5.5.	$\frac{5}{50}$	4.5.5.	$\frac{4\frac{2}{3}}{50}$
Inferior ,, ,, ...	5.4.4.	$\frac{4\frac{1}{3}}{50}$	5.4.5.	$\frac{4\frac{2}{3}}{50}$
Orbital Lobe, Marginal Conv. ...	4.3.3.	$\frac{3\frac{1}{3}}{50}$	4.3.3.	$\frac{3\frac{1}{3}}{50}$
,, ,, Internal ,, ...	4.3.3.	$\frac{3\frac{1}{3}}{50}$	4.4.3.	$\frac{3\frac{2}{3}}{50}$
,, ,, External ,, ...	4.4.4.	$\frac{4}{50}$	4.3.4.	$\frac{3\frac{2}{3}}{50}$
,, ,, Posterior ,, ...	4.4.4.	$\frac{4}{50}$	3.4.4.	$\frac{3\frac{2}{3}}{50}$
Central Lobe, Antr. Gyrus ...	4.4.	$\frac{4}{50}$	5.5.	$\frac{5}{50}$
,, ,, Middle	4.5.	$\frac{4\frac{1}{2}}{50}$	5.5.	$\frac{5}{50}$
,, ,, Posterior	3.4.	$\frac{3\frac{1}{2}}{50}$	5.5.	$\frac{5}{50}$
Marginal Convolution	5.5.5.4.	$\frac{4\frac{3}{4}}{50}$	5.5.5.4.	$\frac{4\frac{3}{4}}{50}$
Gyrus Fornicatus	4.4.4.	$\frac{4}{50}$	4.4.4.	$\frac{4}{50}$
Quadrilateral Lobule	4.5.4.	$\frac{4\frac{1}{3}}{50}$	4.5.4.	$\frac{4\frac{1}{3}}{50}$
Cuneato Lobe	5.4.4.	$\frac{4\frac{1}{3}}{50}$	3.3.4.	$\frac{3\frac{1}{3}}{50}$
Uncinate Gyrus	3.3.4.	$\frac{3\frac{1}{3}}{50}$	3.3.3.	$\frac{3}{50}$
Internal Temporal Convolutions	4.3.4.	$\frac{4}{50}$	5.4.4.	$\frac{4\frac{1}{3}}{50}$

Brain of M. B. (Chronic Mania).

Depth of Grey matter (in 50ths of an inch).

Convolutions.	Right Hemisphere.	Mean Depth	Left Hemisphere.	Mean Depth
1st Frontal...	6.6.5.6.5.4.	$5\frac{1}{6}$	6.6.5.5.5.5.	$5\frac{1}{3}$
2nd ,, ...	5.6.5.5.4.5.	5	5.5.5.4.4 4.	$4\frac{1}{2}$
3rd ,, ...	4.4.5.5.	$4\frac{1}{2}$	5.4.5.5.	$4\frac{3}{4}$
Ascending Frontal	6.5.5.6.5.5.	$5\frac{1}{3}$	6.6.5.5.6.4.	$5\frac{1}{3}$
,, Parietal	5.6.5.5.5.4.	5	4.5.5.5.6.5.	5
Postero-parietal Lobule	5.5.5.5.	5	5.5.5.5.	5
Supra Marginal Conv.	5.5.4.5.	$4\frac{3}{4}$	5.5.6.5.	$5\frac{1}{4}$
Angular Conv.	5.4.4.3.	4	4.5.5.5.	$4\frac{3}{4}$
1st Annectant Conv.	5.5.4.	$4\frac{2}{3}$	5.4.5.	$4\frac{2}{3}$
2nd ,, ,, ...	5.5.5.	5	5.5.4.	$4\frac{2}{3}$
3rd ,, ,, ...	5.6.5.	$5\frac{1}{3}$	4.4.4.	4
Superior Occipital	3.4.4.	$3\frac{2}{3}$	3.4.4.	$3\frac{2}{3}$
Middle ,, ...	4.4.4.	4	3.4.4.	$3\frac{2}{3}$
Inferior ,, ...	5.4.4.	$4\frac{1}{3}$	5.4.3.	4
Supr. Temp. Sphenoid	5.5.5.	5	4.5.5.	$4\frac{2}{3}$
Middle ,, ,, ...	5.5.4.	$4\frac{2}{3}$	5.5.5.	5
Inferior ,, ,, ...	5.4.4.	$4\frac{1}{3}$	5.3.4.	4
Orbital Lobe, Marginal Conv. ...	3.3.3.	3	3.3.3.	3
,, ,, Internal ,, ...	4.4.3.	$3\frac{2}{3}$	4.4.4.	4
,, ,, External ,, ...	4.4.4.	4	4.5.5.	$4\frac{2}{3}$
,, ,, Posterior ,, ...	5.5.3.	$4\frac{1}{3}$	5.4.4.	$4\frac{1}{3}$
Central Lobe, Antr. Conv. ...	6.6.	6	6.5.	$5\frac{1}{2}$
,, ,, Middle ,, ...	5.5.	5	5.5.	5
,, ,, Posterior ,, ...	5.5.	5	5.5.	5
Marginal Convolution	5.5.5.	5	5.4.5.	$4\frac{2}{3}$
Gyrus Fornicatus	4.4.4.	4	4.4.4.	4
Quadrilateral Lobule	4.4.4.	4	3.4.4.	$3\frac{2}{3}$
Cuneate Lobe	4.4.4.	4	3.4.4.	$3\frac{2}{3}$
Uncinate Gyrus	4.4.3.	$3\frac{2}{3}$	4.3.4.	$3\frac{2}{3}$
Internal Temporal Convolutions	5.4.4.	$4\frac{1}{3}$	4.4.4.	4

Brain of J. J. (Senile Dementia), *Continued.*

Relative depth in the various groups of Convolutions.

	Right.	Left.
Frontal Lobe	$\frac{5\frac{1}{2}}{50}$	$\frac{5\frac{1}{2}}{50}$
Parietal ,, ...	$\frac{5}{50}$	$\frac{5}{50}$
Annectant Gyri	$\frac{4\frac{1}{2}}{50}$	$\frac{4\frac{1}{2}}{50}$
Occipital Lobe	$\frac{4}{50}$	$\frac{4}{50}$
Temporo-Sphenoidal Lobe	$\frac{5}{50}$	$\frac{5}{50}$
Orbital Lobe	$\frac{4}{50}$	$\frac{3\frac{1}{2}}{50}$
Central ,, ...	$\frac{4}{50}$	$\frac{5}{50}$
Marginal Convolution, Gyrus Fornicatus, Quadrilateral Lobule	$\frac{4\frac{1}{2}}{50}$	$\frac{4\frac{1}{2}}{50}$
Cuneate Lobe, Uncinate Gyrus	$\frac{4}{50}$	$\frac{3}{30}$
Internal Temporals	$\frac{4}{50}$	$\frac{4\frac{1}{2}}{50}$
The Hemispheres	$\frac{4\frac{1}{2}}{50}$	$\frac{4\frac{1}{2}}{50}$

Average depth of the whole Cortical Substance = not quite $\frac{1}{10}$ inch.

Brain of M. B. (Chronic Mania), *Continued.*

Relative depth in the various groups of Convolutions.

	Right.	Left.
Frontal Lobe	$\frac{5}{50}$	$\frac{5}{50}$
Parietal ,, ...	$\frac{5}{50}$	$\frac{5}{50}$
Annectant Gyri	$\frac{5}{50}$	$\frac{4\frac{1}{2}}{50}$
Occipital Lobe	$\frac{4}{50}$	$\frac{4}{50}$
Tempero-Sphenoidal	$\frac{4\frac{2}{3}}{50}$	$\frac{4\frac{2}{3}}{50}$
Orbital Lobe	$\frac{4\frac{3}{4}}{50}$	$\frac{4}{50}$
Central ,, ...	$\frac{5\frac{1}{3}}{50}$	$\frac{5}{50}$
Marginal Convolution, Gyrus Fornicatus, Quadrilateral Lobule	$\frac{4\frac{1}{3}}{50}$	$\frac{4\frac{1}{4}}{50}$
Cuncate Lobe, Uncinate Gyrus	$\frac{4}{50}$	$\frac{4}{50}$
Internal Temporals	$\frac{4\frac{1}{3}}{50}$	$\frac{4}{50}$
The Hemispheres	$\frac{4\frac{1}{2}}{50}$	$\frac{4\frac{1}{2}}{50}$

Average depth of the whole Cortical Substance = not quite $\frac{1}{10}$ inch.

It remains for me now to adduce, as the last division of my subject, a few conclusions which seem to be indicated by such observations as I have been able to make. These must of necessity be few in number, for such work on this subject as I have accomplished, has been done with the view of demonstrating the efficacy of my method, leaving other questions which naturally arise as matter for future observation. It will be noticed with reference to the brains, the examination of which I have recorded, that they all represent the organ in a morbid condition; and hence for the present, I must entirely exclude all questions of comparison between the latter state as contrasted with that of health. Such investigation however as I have been able to make, has not been without effect in bringing before me certain facts which I may perhaps at present be permitted to notice, as being, so far as they go, very conclusive and not devoid of interest. Nothing has presented itself more forcibly to my mind, as the result of my method of precedure than the fact, that the depth of the grey matter of the Cerebrum varies in different situations; and that this variation is not accidental or irregular, but is in all cases in accordance with a definite plan. It may be stated generally that as regards the upper surface of the hemispheres, the depth of the cortical layer in the frontal and parietal lobes and in the annectant gyri is not subject to much variation, though as a rule, that of the two former is somewhat greater than in the latter situation. But when, passing backwards from the annectant gyri, the occipital lobe is reached, at once a difference is found in the shape of a marked decrease in the depth of this layer. The change is always sudden, and, so far as my experience goes, it is invariable. We next come to the temporo-sphenoidal lobes, and here again, as compared with the last, we find invariably an alteration in thickness; but in this instance it is in the opposite direction; the temporo-sphenoidal convolutions are in this respect always higher than the occipitals. Pursuing the order which I have followed throughout, the orbital lobes and the convolutions they comprise present themselves for examination. Here, as compared with the last, the result will be found to indicate a diminution in the depth of the grey matter. This is in all cases very marked, and more especially with respect to the

marginal convolutions where the grey covering is very thin indeed. The central lobes, or islands of Ryll, come next in order; and here we find a condition which contrasts very forcibly with that which was observed in the orbital lobes. The grey layer is here always deep; in most cases indeed, I think it will be found to be at least as deep as in any other situation of the hemispherical ganglion. There is a point also which I wish to notice in passing, and that is, pallor of the grey substance in this situation, and as a consequence want of that definition in its depth, which is always so well marked in other parts. I have always found this to be the case, but at present must be content with stating the fact for I do not as yet know how it is to be explained. Passing now to the internal aspect of the hemispheres, we find the marginal convolutions, the gyri fornicati and the quadrilateral lobules. I have but little to say with respect to these; in them the layer of grey matter is of medium thickness, and corresponds pretty closely in this respect with the temporo-sphenoidal convolutions. Proceeding backwards from these however, we find, as was the case in the superficial aspect of the hemispheres, so here, that the depth of the cortical layer decreases. The cuneate lobes and uncinate gyri invariably show a falling off, and this is especially noticeable in the last named situation. Lastly, we have to consider the internal temporal convolutions; and here we find a distinct rise in depth of grey matter, as compared with the cuneus and uncinate gyrus; it does not as a rule, however, present much thickness in this situation, the contrast being due to the very shallow layer possessed by the uncinate. The general arrangement as above described will be found borne out by the four brains, the examination of which I have recorded; and I venture to think, that in the majority of cases it will be found correct. In making this statement it may possibly be thought I am forgetful of the fact, that the brains above referred to represent in each case a morbid condition of the organ. But in truth, I cannot think that I am arguing on a false principle or on insufficient data, for it will be observed that in all four cases, the remarks I have made hold good. The brain of J. M. H. S., who died of acute bronchitis, occurring in the course of acute delirious mania, presented no change or abnormality which we were able to detect;

the progress of the case was too short and rapid to admit of perceptible structural change. Very different in all respects, were the brains of J. B. and J. J., who died in a state of senile dementia; and yet in these three cases, as well as in that of M. B., who died during the course of chronic mania, the variations I have above described were found to exist. Such a fact as this furnishes, I think, pretty conclusive evidence of the general correctness of my statement, especially as I may add further, that in a brain which I have in part examined, and which was not morbid in the sense in which I have before used the word, I found distinct indication of a similar condition and arrangement of the cortical layer.

In the second place, I would point to the fact, and this I do at present only as suggestive of further inquiry, that in the patient who died of acute mania, I have found the average depth of the grey matter to be greater than in the other cases, which had pursued a long and chronic course.

In cases of partial wasting it will be important, and as I hope to show later, practicable, to estimate the extent of the degenerative process more surely than can be done by a superficial examination; and on the other hand, to be able to exclude wasting, in some cases in which appearances are doubtful or deceptive.

It were easy to add to these suggestions for further research; but because it is easy, it is therefore unnecessary. My object for the present will have been fully attained, if I have been successful in furnishing an instrument, which may be of assistance however slight to the physiologist and the pathologist, and an aid however humble in the elucidation of those questions to which I have referred.